CALIFORNIA DIVISION OF MINES AND GEOLOGY
FAULT EVALUATION REPORT FER-240

Holocene Faulting on the Cucamonga, San Jacinto and related Faults, San Bernardino County, California.

by
John L. Burnett and Earl W. Hart
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INTRODUCTION

The study concerns recently active faults in the Devore, Cucamonga Peak and Mt. Baldy 7½' quadrangles. The study area is in southwesternmost San Bernardino County (Figure 1). Faults evaluated include the Cucamonga, San Jacinto, Tokay Hill, and Peters faults and portions of the San Jacinto, San Andreas, Glen Helen, and Lytle Creek faults (Maps 2a, b, c). These faults were previously zoned under the Alquist-Priolo Earthquake Fault Zoning Act[1] in 1974 (Devore quadrangle) and 1979 (Cucamonga Peak and Mt. Baldy quadrangles) (see Figures 1a, b, c).

The purpose of this Fault Evaluation Report is to review the adequacy of faults and zones shown on the 1974 and 1979 Earthquake Fault Zone (EFZ) maps in light of new information that has become available recently (Maps 1a, b, c and 2a, b, c). Recent work by Morton and Matti (1987, 1991a, 1991b) show Holocene strands of the Cucamonga Fault to lie outside the Earthquake Fault Zones in each of the three quadrangles. These and other workers also provide new data on the San Jacinto, San Andreas, Glen Helen, Lytle Creek and other faults in the Devore quadrangle.

The 1974 Devore EFZ map was compiled entirely from the work of others and showed all known Quaternary faults (Map 1a). Beginning with zones established in 1977, zoning policy was changed so that only those faults considered to be Holocene-active and reasonably well defined as surface features would be zoned (Hart, 1994). The Mt. Baldy and Cucamonga Peak EFZ Maps were prepared under the new criteria based on the evaluation of D.L. Smith (1978). Sources of data for these early maps is only briefly discussed.

Responsibilities for this fault evaluation study is as follows: Burnett was primarily responsible for the evaluation of the Cucamonga and related faults. Hart reviewed his work and later made additions. Hart was largely responsible for the assessment of the San Jacinto, San Andreas and other northwest-

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[1] The name of the Act was changed on 1/1/94 from the Alquist-Priolo Special Studies Zones Act. The name of the zones also was changed from Special Studies Zones to Earthquake Fault Zones.

trending faults, although Burnett did the preliminary data-gathering.

Geologic Setting

The study area occupies the eastern end of the San Gabriel Mountains, which is bounded by the Cucamonga thrust fault on the south and the San Andreas fault on the northeast (Figure 2). The region is broken by northwest trending right-lateral faults (San Jacinto, Glen Helen, Lytle Creek faults) and less dominant but still significant northeast trending left-lateral faults. The overall result is a shear couple with north-south shortening (compression) and east-west extension. Uplift of the San Gabriel Mountains with thrusting along the southern margin is the principal geomorphic and tectonic effect of this compression. The regional tectonics are discussed in detail by Matti and others (1992).

Crystalline basement rocks are exposed north of the Cucamonga Fault zone, between Cajon and Lytle Creeks and northeast of the San Andreas fault. These rocks include schist, gneiss, granulite and pods of marble which are intruded by quartz monzonite and quartz diorite. Large areas of these rocks are foliated and display cataclastic textures. Sequences of Tertiary conglomerate, sandstone and mudstone overlie or are faulted against the crystalline bedrock in several areas. Overlying the older rocks are Quaternary alluvial fan and stream deposits.

Work by Matti and others (1982) and Morton and Matti (1987, 1991a, 1991b) have separated the Quaternary deposits in the area into 13 mappable units and assigned relative ages to each. This breakdown is based on six criteria: 1) topographic position; 2) degree of erosional dissection; 3) preservation of primary depositional features; 4) structural and temporal relations in various strands of the Cucamonga Fault zone; 5) differences in lithology; and 6) differences in soil-profile characteristics. The youngest units include modern alluvium and alluvial fans of Holocene to latest Pleistocene age (0-13,000 years) (see Table 1). An older group includes well-dissected younger alluvial fans of mostly latest to mid-Pleistocene age (13,000 to more than 300,000 years). The oldest alluvial fans of mid to early Pleistocene age are extremely dissected. These units are extremely useful in determining the activity of various fault strands.

Table 1. Relative ages of principal Quaternary alluvial units of Morton and Matti (1987, 1991a, 1991b) and Matti and others (1982).

Unit	Description	Estimated Age
Qw, Qa, Qf	Alluvium of active channels and fans; undissected surfaces	Modern
Qyof	Young alluvial fans; slightly to moderately dissected	Holocene to late Pleistocene
Qyf_{3-5}	Alluvial fans with slight dissection	Late Holocene
Qyf_2	Alluvial fan; moderate dissection	Early to mid-Holocene
Qyf_1	Alluvial fan; moderate dissection	Latest Pleistocene to early Holocene
Qof_{1-3}	Alluvial fans; well dissected	Mid to late Pleistocene
Qdf_{1-2}	Alluvial fans; extremely dissected	Mid to early Pleistocene

SUMMARY OF AVAILABLE DATA

Cucamonga Fault and related faults

The Cucamonga Fault zone extends along the front of the San Gabriel Mountains from San Antonio Heights to Lytle Creek Canyon. The east and west terminations of the fault zone are somewhat unclear. To the east, the fault stops about one half mile short of the Lytle Creek Fault and appears to be truncated by it (Map 2a). The western end of the Cucamonga fault is concealed by late Holocene alluvial fans (Map 2c). Further to the west, beyond the study area, thrust displacement begins along the Sierra Madre Fault Zone (Figure 2).

Except for the westernmost end in San Antonio Heights, this fault had previously been zoned (CDMG 1974, 1979a and b) based on mapping by Morton (1973 and 1976) and Smith (1978). Later work by Morton and Matti (1987, 1991a and 1991b) modified the locations of some of these traces and added or extended several others (Figures 2a, b, c).

Morton and Matti mapped three principal fault strands which are largely defined by south-facing scarps in Holocene to latest

Pleistocene alluvium (1987, 1991 a and b). The scarps and evidence of fault recency are plotted on Maps 2a, b, c.

Documented evidence for large pre-historic earthquakes along the Cucamonga Fault have only recently been found. Using alluvial fans, soil stratigraphy, and increasing scarp heights with age, 18 separate, recognizable events were inferred within the last 12,600 years before present on three main strands (A, B, and C) (Matti et al, 1982; Morton and Matti, 1987). The fault scarps were highest where the faults disrupt older alluvial units and progressively lower in younger units. Strand C (the southernmost) is considered to be the youngest and most active, although all offset Holocene fans.

Matti and others (1992) state that thrust faulting along the north-dipping Cucamonga Fault zone has moved at the rate of 5 mm/year for the last 13,000 years and the rate could be greater. They conclude that earthquakes with vertical displacements of 2 m occur every 625 years.

Consultants trenched seven development sites on or near these mapped traces and found evidence for recently active faults at five of them (AP 2005, 2125, 2126, 2431, and 2750). Trenches at four of the sites (AP 1529, 2015, 2123, 2124) did not reveal any faults in older alluvium but they may have missed the faults. Report AP 2058 did not report any faults in three short trenches in alluvium on a south branch of the fault, but one trench did show a sharp break in slope (scarp?). These trench investigations are summarized on Maps 2a, b and c and in the Appendix.

Special mention is made of site AP-2126 on the Mt. Baldy quadrangle, where trenching by Leighton and Associates (LAA) and Richard Mills Associates (RMA) led to different conclusions. These data are summarized on Map 2c and the Appendix. Based on 943 feet of shallow trenching, LAA concluded that the main fault of Morton (1976) was active, offsetting alluvial units Qyf_1 and Qyf_2 of Morton and Matti (1987). LAA did not verify the northerly trace of Morton and Matti (Map 2c) (Morton, 1976, does not show this trace). They did, however, identify a more northerly trace (shown in brown on Map 2c), which they considered to be active. Drew Smith (1978) questioned this trench data and after reviewing air photos recommended against zoning the northernmost trace (see Map 3c).

Later deep trenching (to 15 and 20 feet) by RMA verified the Holocene activity of Morton and Matti's main trace, although RMA's location locally differed from the latter by 100 feet or so (Map 2c). RMA showed the fault to dip gently to steeply north at seven locations in Qyf_1 and Qyf_2. They showed that the concealed southwest extension of Morton and Matti's northern trace did not exist in early to mid-Holocene alluvium and concluded that the concealed extension was not a surface-active trace. They also trenched LAA's northernmost trace and showed that Qyf_1 and Qyf_2 alluvium was unfaulted. Two of their trenches were close to LAA's shallow trenches.

The Powerline fault of Morton and Matti (1987, 1991b) is a subsidiary thrust fault just south of the Cucamonga fault. It is shown to be a south-facing scarp in Qyf_1 alluvium (latest Pleistocene to early Holocene) and to dip 25-30° N. It does not offset early- to mid-Holocene alluvium (Qyf_2) to the west. Trenching by Rasmussen and Associates at site C-898 verified that the north dipping thrust offset late Pleistocene gravels and a degraded scarp which they considered to be inactive during the last 15,000 years based on the scarp slope-angle (13-14°). They did not recommend a building setback.

Another secondary thrust fault was mapped by Morton and Matti (1987) on the Mt. Baldy quadrangle (Map 2c) based on a south-facing scarp in a mid- to early-Holocene fan deposit. This is just south of the main traces and east of Cucamonga Creek.

The Red Hill fault was previously mapped by Morton (1976a) and earlier workers as a mostly concealed fault and groundwater barrier that extends from Red Hill (which lies south of the study area) northeastward for 12 km (8 mi). Only the northeastern 1 km of the fault is exposed as a surface trace (Map 2b). D.P. Smith (1978), who evaluated the Red Hill fault for possible zoning, provides an in-depth review of the literature and concludes that: 1) Only the eastern end of the fault was Holocene and 2) Most of the fault is concealed and probably was active during Holocene time. He recommended zoning the eastern end, which was done in 1979 based on the work of Morton (1976b) (Map 1b). Morton and Matti (1987, 1991b) remapped the eastern end of the fault as the Etiwanda Avenue fault (Map 2b). They show the fault to offset Holocene alluvial fans designated as Qyf_1 and Qyf_2.

Although most of the Red Hill fault is concealed and inferred, the City of Rancho Cucamonga set up a regulatory zone to require fault studies. Several sites have been trenched on or near the fault, but none have uncovered any faults. Three of the sites are on the Cucamonga Peak quadrangle (see C-652, C-721 and C-738 on Map 2b and Appendix). Other sites lie to the southwest (C-664, C-666, C-667 -- not shown, but listed in Appendix).

Another groundwater barrier is Barrier J of Dutcher and Garrett (1963), which they show as an inferred, concealed fault in older alluvium (Qoal). Its projected surface location is shown on Map 2a. Barrier J is inferred to offset the water table about 200 feet (northwest side up). According to Hadley and Combs (1974), microearthquakes align with this feature, suggesting to them that the barrier is related to the Cucamonga fault system. More recent earthquakes also show this alignment (see Figure 3; Magistrale and Sanders, 1994). Although shown on an early map of Morton (1974), Morton and Matti (1987, 1991a) do not show the barrier on later maps.

San Jacinto Fault Zone

This major zone of northwest-trending, right-lateral faults is over a hundred miles long, extending from its near connection with the San Andreas fault just north of the study area (Figure 2) southeastward past the Salton Sea (Jennings, 1992). Many of its members are major active faults in themselves. Matti and others (1992) provide an excellent summary of this fault zone, pointing out that it has had 25 km of right-lateral displacement in the Perris block since early Pliocene time and a Quaternary slip rate of 8 to 12 mm/yr.

Within the Devore quadrangle, the San Jacinto Fault Zone is complex, consisting of three named strands -- the Lytle Creek, San Jacinto and Glen Helen faults, from west to east -- in a zone 2-3 miles wide. According to Matti and others (1992), the name "San Jacinto" traditionally has been applied to the central fault of the zone, which consists of two or more closely spaced fault strands that form impressive shear/breccia zones in crystalline rock (Map 2a). The Glen Helen fault strand, which forms scarps and sag ponds to the east, is generally regarded as the most active strand, although the Lytle Creek fault to the west offsets latest Pleistocene alluvium and has a slip rate of about 2 mm/yr.

All of these strands of the San Jacinto Fault Zone were zoned by CDMG in 1974 under the Alquist-Priolo Act. The zones were compiled based on unpublished work of Morton (1973; later published in Morton 1974 and 1976) and published maps of Dutcher and Garrett (1963) and Sharp (1972). These EFZs were established under different criteria and were 1) wider than later zones and 2) based on assumed Quaternary activity.

Lytle Creek Fault. This fault, which is in the Devore quadrangle, was zoned by CDMG in 1974 based on the unpublished mapping of Morton (1973). Based on the mapping of Dutcher and Garrett (1963) and Sharp (1972), the Lytle Creek fault was extended to the southeast as a concealed fault that merges with the San Jacinto Fault Zone (Map 1a). Later mapping by Morton and Matti (1987 and 1991a) is similar, but differs in detail. Also, they do not show the fault to extend southeast of Nealeys Corner. They show the fault as a scarp in a latest Pleistocene to early Holocene alluvial fan deposit (Qfy_1) just south of Texas Hill, although the fault is shown to be concealed by the same unit just north of Texas Hill. Elsewhere, the fault is shown to offset older crystalline rocks except where concealed by Holocene alluvium.

Matti and others (1992) consider the Lytle Creek fault to be a west branch of the San Jacinto Fault Zone and presume it to be right-lateral. Metzger and Weldon (1983) have studied the fault where it forms a 5 m-high scarp in late Pleistocene deposits (50,000-60,000 ybp) and conclude that it has a maximum right-slip rate of 2.5 mm/yr. and a vertical component of 0.04 to 0.1 mm/yr.

Only one consulting report investigated the possible southern extension of the Lytle Creek Fault at Nealey's Corner (AP 1902). No evidence of surface faulting was found in two trenches totaling 255 feet in length but the trenches were short enough that the buried fault could have been missed. The consultant estimated the age of the unfaulted alluvium to be 3000 to 4000 years old.

San Jacinto Fault. Most of the traces of this fault were zoned based on unpublished mapping of Morton (1973) in the Lower Lytle Creek Ridge area (Map 2a). In Sycamore Flat and to the southeast, where the fault is largely concealed by Holocene alluvium, the mapping of Dutcher and Garrett (1963) and Sharp (1972) also was used. The alluvial locations were based on assumed positions of groundwater barriers or on projections of distant fault traces rather than on surface features.

Recent mapping by Morton and Matti (1987, 1991a) is similar but differs in detail from Morton's early 1973 and 1976 mapping (Map 2a). The recent maps show more traces but do not provide new data on recency. Morton and Matti only identify two areas where Holocene deposits may have been displaced -- just northwest of the Glen Helen Rehabilitation Facility and northwest of Sycamore Flat. However, both of these localities may be drafting errors as adjacent Holocene deposits are not shown to be offset. The youngest unit clearly mapped as offset is in SE¼ section 31 where granodiorite is thrust over middle Pleistocene alluvium (Qdf_2) along a 35° N-dipping thrust. Two other nearby fault strands to the southwest are not shown to be offset by this same unit. Elsewhere, Holocene deposits are shown to conceal the fault.

Airphoto interpretations and field mapping by Rasmussen and Associates (1994; see AP-2751) identifies three fault traces they believe to be active -- the main trace (which they call the Verdemont Ranch fault) and two subsidiary traces to the east (Map 2a). Their Verdemont Ranch fault is similar to the eastern San Jacinto trace and is shown to offset "young alluvium" (Qal). The two shorter traces to the east are based on east-facing scarps in older alluvium. The traces of Rasmussen were not trenched, although a concealed trace of Dutcher and Garrett (1963) was trenched just west of the Glen Helen Rehabilitation Facility and no fault was identified in alluvium estimated to be at least 5,000 years old (see AP 2751, Map 2a).

The Verdemont Ranch trace is generally on trend with a fault to the southeast discontinuously exposed in young alluvium near Muscoy (Map 2a), which was mapped by Wes Reeder and Donn Schwartzkopf (1994 personal communication). According to Reeder, the fault offsets alluvium radiocarbon age-dated as 13,000 ybp. Photographs submitted by Schwartzkopf show faults in two or three places extending up into the upper soil unit. So a tentative assumption that the fault near Muscoy is Holocene-active seems reasonable (also see below under Air Photo Interpretations).

The San Jacinto fault also was trenched in Sycamore Flat and reported to offset Holocene alluvium by Jeff Johnston (personal communication, 1994) (Map 2a). The fault was identified in five trenches as offsetting "recent faulted units" in a zone 30 to 100 ft wide (letter of 6/16/94). Radiocarbon dating of charcoal in the northwest trench indicates that alluvium 490 ± 70 ybp is faulted below 8 ft of depth. This is overlain by unfaulted alluvium dated at 280 ± 70 ybp.

Additional traces of the San Jacinto fault were trenched extensively at the El Rancho Verde Country Club by Rasmussen and Associates (1982, 1994; AP 2795 and 2796) revealing several Holocene fault traces (Map 2a). This fault has been mapped as a northeast facing scarp to the southeast by Sharp (1972) and verified by trenching in alluvium just south of Highland Avenue (AP 1736 of Rasmussen, 10/3/84 report -- just off of Map 2a; not listed in Appendix). Rasmussen (1982 and 1994) excavated 6,741 linear feet of trenches at El Rancho Verde CC revealing a main trace (northeast facing scarp) which veered to the west near the country club building. Subsidiary traces also were exposed in young alluvium indicating a complex zone of faults consistent with a right-step connection with the Glen Helen fault and perhaps the Verdemont and Muscoy traces. Weak tonal lineaments and scarps, some of which may be channel-related, may suggest specific connections in this stepover (Map 2a; also see discussions below). The west extension of the continuous El Rancho Verde trace is projected to the west as tonal lineaments, which were not trenched by Rasmussen. However, the channel margin interpreted as a concealed fault by Sharp (1972) and Dutcher and Garrett (1963), which was zoned in 1974, was not verified in a trench to the west by Rasmussen and Associates (1977; AP 488)(see Map 2a and Appendix).

The only other trenched site along the San Jacinto fault is in the northwest corner of the Devore quadrangle near Scotland, where a 590 ft-long 10-foot deep trench exposed a 98-foot wide fault zone in Quaternary alluvium (G.A. Clopine, 1987; AP 2062). One of the traces also offset alluvium judged to be Holocene, but not younger than 200 years. The other traces did not offset this younger unit. The fault reportedly forms a "significant barrier" to groundwater with the northeast side higher. The fault zone aligns with the northern trace that defines the breccia zone of

Morton and Matti (1991a). However, they do not indicate that the young stream alluvium or adjacent Holocene fans are offset.

Glen Helen Fault. In the Devore quadrangle, the Glen Helen fault is probably the most active element of the San Jacinto fault zone (Matti and others, 1992; Morton and Matti, 1987 and 1991a). The fault is about 13 miles long, much of which is concealed (Figure 2). It offsets Holocene alluvium (Qyf_1 and Qf) in several places, including a well-developed scarp north of the Glen Helen Regional Park (Map 2a).

The only trenching project completed on the Glen Helen fault is at Glen Helen Regional Park where Rasmussen and Associates (1992; AP 2645) excavated 2,059 feet of trench and exposed numerous faults across a low hill composed of Plio-Pleistocene San Timoteo Formation(?). Holocene sag pond deposits are truncated along the west margin of the Hill in two trenches, confirming the location of the main active fault (Map 2a). A minor west-dipping reverse(?) fault that offsets latest Pleistocene alluvium was identified in the long trench 350 ft northeast of the main trace, but no Holocene alluvium was present to date the most recent activity. The long trench also revealed no evidence of the northwest projection of Morton's (1973) fault which was zoned in 1974. This fault, also mapped by Morton and Matti (1991a) as a bedrock fault, supposedly was trenched to the southeast, but Rasmussen's fault appears to be located about 200 ft to the southwest of Morton's trace (Map 2a). Rasmussen trenched a "lineament with topographic expression" that is only visible in the granitic bedrock hills. Trenching exposed faulted Pleistocene alluvium in Trench 3, but younger alluvium which may have existed was removed by grading. Pleistocene alluvium in Trench 8 located 300 ft to the north was not faulted, however.

San Andreas Fault Zone

Only a small segment of this major right-lateral fault lies in the study area in the northeast part of the Devore quadrangle. According to Weldon and Sieh (1985), the fault has a slip-rate of 24.5 $\pm$ 3.5 mm/yr in the last 14,400 years at Cajon Pass, just north of the study area. The fault was zoned under the AP Act in 1974 based on the mapping of Hope (1969) and Morton (1973) (Map 1a). The work of Morton was later published in Morton (1974) and revised slightly by Morton and Matti (1991a). They show the San Andreas fault zone (Map 2a) as a series of subparallel and branching faults more than a mile wide. The main trace is defined by linear scarps and offsets Holocene alluvium in several places. To the northeast are several traces -- both linear (high angle?) and thrust -- apparently of various ages. Most only cut Tertiary and older rocks, but two cut Holocene (Qyf_1) alluvium. Two faults in sections 23, 26 and 27 are associated with northeast-facing scarps in bedrock. The mapping of R.J. Weldon

(1986) is similar but more detailed (scale 1:12,000) than Morton and Matti (Map 2a). He also shows two subsidiary traces northeast of the main trace as offsetting Holocene units (Qhf).

Several trench investigations have been made along the San Andreas fault. The only one to report active faults was AP 1507 (Rasmussen), which reported faults in two places (Map 2a). The main trace was verified where mapped by Weldon and a secondary trace was found about 300 feet to the northeast. The other trench reports (AP 1874, 2014, 2063, 2356) did not report active faults -- even on the main trace of the San Andreas.

Tokay Hill and Peters Faults

The Tokay Hill and Peters faults lie to the southwest of the San Andreas and appear to branch from it. They were previously zoned based on the mapping of Hope (1969) and Morton (1973)(Map 1a). The faults have been remapped by Morton and Matti (1991a) without significant change. Both faults are delineated by prominent north to northeast-facing scarps in Holocene alluvium (Qyf_1 and Qyf_2). Neither fault is shown to offset Qyf_3 alluvium (late Holocene). Matti and others (1992) indicate that these faults are probably normal, although the Tokay Hill fault may be reverse near its juncture with the San Andreas fault.

Pleistocene alluvium disrupted by the Tokay Hill Fault has been confirmed by trenching and surface examination (AP 649). Younger (Holocene) units were not reported in this study.

Only one trench was excavated across the Peters Fault and Holocene rupture was found based on faulted organic-rich colluvium at the base of the surface scarp (AP 2756). There have been two other exploratory trenches, AP 1860 and AP 1885, (AP 1885 is not precisely locatable with the data on file; the approximate location was confirmed by Wes Reeder, personal communication) dug near the Peters fault but no surface rupture was found. The best evidence for Holocene activity is the prominent scarp that is developed in Holocene alluvium.

Bedrock Faults North of the Cucamonga Fault

Morton (1974, 1976) and Morton and Matti (1987, 1991a, 1991b) identify numerous faults in bedrock north of the Cucamonga fault and west of the Lytle Creek fault. From west to east, these include the Stoddard Canyon-Lytle Creek, Demens Canyon, Icehouse Canyon, Day Canyon, Duncan Canyon and several lesser faults (Maps 2a, b, c). None of these faults were previously zoned. All of these faults are in crystalline bedrock and none are shown to offset Quaternary units, although few Quaternary deposits exist in this part of the study area.

We did not have adequate air photos for most of this area (Mt Baldy and Cucamonga quadrangles) so our evaluation of most of these faults is based on the work of Morton and Matti. See below for air photo interpretations on the Devore quadrangle.

AIR PHOTO INTERPRETATIONS AND FIELD OBSERVATIONS

Photointerpretations were based largely on the following vertical, black and white, 1:24,000-scale air photos of the U.S. Department of Agriculture flown in late 1952 and early 1953: AXL 31K-139 to 148, 34K-36 to 43 and 68-74, 35K-82 to 90 and 113 to 117, 36K-135 to 143, 39K-111 to 113 and 154-156, 51K-102 to 107. These covered all of the known active and previously zoned faults in the study area. The faults of unknown activity north of the Cucamonga fault on the Cucamonga Peak and Mt. Baldy quadrangles were not evaluated by photointerpretation due to incomplete photo coverage. Other air photos checked are the black and white, vertical, 1:12,000-scale photos of the U.S.G.S. Water Resources Division flown June 1967: WRD 5232-5254, 5405-5420, and 5549-5570. The latter only covered the San Jacinto fault zone.

Our photointerpretations are shown in purple on Maps 2a, b and c. A check-mark (✓) means we could verify the traces of others as recently active faults; NV indicates faults that could not be verified as recently active. Other symbols are explained on Map 2b.

Field observations were conducted by Burnett over a period of 3 days in March 1994 and were primarily confined to field-checking the Cucamonga fault scarps.

Cucamonga and related faults.

Recent fault scarps on the Cucamonga fault that were mapped by Morton and Matti (1987, 1991b) are apparent on the U.S. Department of Agriculture 1952-1953 aerial photographs (Maps 2a, b, c). At this time, the scarps were not yet graded and must have been obvious to any careful observer on the ground. Since that time, however, the western two-thirds of the Cucamonga fault has been extensively modified by development. The subdivisions built after the Alquist-Priolo Act went into effect have legal setbacks, but streets, greenbelts and other developments have modified the scarps. Development completed before the zones were established have houses situated across the scarps in some places (Van Buskirk and Brooks, 1994). Most of the Holocene fault traces of Morton and Matti could be verified on airphotos where they offset younger alluvial fans (Maps 2a, b, c). We were unable to verify the Holocene trace of Leighton (AP-2126) on the Mt. Baldy quadrangle (Map 2c).

In addition, to generally verifying the faults and scarps of Morton and Matti, two other fault features were mapped by us. At the west end of the Cucamonga fault is a south-facing scarp that appears to truncate young alluvium (Qyf_1) just south of Morton and Matti's trace. This feature also was verified on the ground. Another scarp appears to truncate a Qyf_1 alluvial fan against crystalline bedrock in SE¼ sec. 15 on the Devore quadrangle, but it was not field checked.

The Etiwanda Avenue fault is verifiable on the air photos as a low southeast-facing scarp in young alluvium with a sharp tonal contrast (groundwater barrier?). No evidence was observed that would suggest the fault connects as a surface feature with the Red Hill fault to the southwest.

The Powerline fault scarp of Morton and Matti could not be verified on airphotos (Map 2b). Neither could we verify the northern trace of Leighton and Associates (C-319; Map 2c) which, if active, presumably would offset the Qyof and Qyf_1 surfaces.

<u>Lytle Creek Fault</u>

The Lytle Creek fault is the most westerly branch of the San Jacinto fault zone. The most active segment of this fault is geomorphically expressed by a linear scarp in young terrace/fan deposit (Qyf_1) and right-laterally deflected drainages and ridges southeast of Texas Hill (Map 2a). To the south, the main trace is defined by a eroded graben and stream-modified scarps in young alluvium. South of Nealeys Corner, scarps and tonal lineaments in Holocene alluvial fan deposits of Morton and Matti (1991a) suggest position of the fault, although these features may be fluvial in part. To the northwest, the Lytle Creek fault splits into two strands, the eastern of which seem to be the most active. The western strand does not appear to be active northwest of section 36, lacking geomorphic features that might suggest Holocene activity.

<u>San Jacinto Fault</u>

This fault, as mapped by Morton and Matti (1987, 1991a), consists of multiple strands that are partly interconnected with the adjacent Lytle Creek and Glen Helen faults (Map 2a). Although the San Jacinto fault may be geologically the most important fault of the San Jacinto fault zone, it does not appear to be the most active. The principal strand of the San Jacinto fault is geomorphically defined by linear drainages and valleys, a discontinuous scarp, and a few right-laterally deflected drainages in the central and northwestern part of the quadrangle. The North Fork of Lytle Creek does not appear to be offset where a Holocene fault was reported near Scotland (AP 2062), although a weak tonal lineament is perceptible on trend in the alluvium of the creek. The fault is largely concealed by modern alluvium of Lytle Creek in sections 25 and 26.

Sycamore Flat appears to be an anomalous valley that was partly closed by a shutter ridge. Only faint tonal lineaments can be observed in the young alluvium on the USDA (1953) air photos. These tonal features generally align with the trenches of J. Johnston who reported faulted recent alluvium in five trenches and dated one of the faulted units as late Holocene (see discussion under Summary of Available Data).

To the southeast, the main trace is generally defined by a scarp, broad trough, and break in slope near Verdemont. At Glen Helen Rehabilitation Facility (GHRF), the active trace is suggested by a linear trough and right-laterally deflected drainage at the crest of the hill. Other traces marked by east-facing scarps in older and younger alluvium suggest an interconnection with the Glen Helen fault. Southeast of GHRF, the San Jacinto fault is largely concealed by modern alluvium, although weak tonal lineaments and scarps suggest both its position and recency in remnants of latest Pleistocene to Holocene alluvium.

A westerly set of tonals may be related to the active faults trenched by Rasmussen (AP 2796) near the El Rancho Verde Country Club, which coincides with a curvilinear scarp in alluvium. An easterly set of linear tonal features appear to connect with the faults in alluvium reported near Muscoy by Reeder and Schwartkopf (1994) in the San Bernardino North quadrangle. These features may define elements of a surface stepover between the San Jacinto fault to the south and the Glen Helen fault to the north.

No evidence was observed on the airphotos that would suggest that the subsidiary traces of the San Jacinto fault are active. Some of these can be recognized as faultline features, but none show a systematic sense of recent offset or subtle geomorphic features suggestive of Holocene activity.

Glen Helen Fault

This is the easternmost branch of the San Jacinto fault zone and clearly the most active and best-defined strand of that zone within the Devore quadrangle. A mile-long linear scarp in Holocene alluvium in and northwest of Glen Helen Regional Park (GHRP) demonstrates that the fault is active. To the northwest of Devore, the fault is defined by the prominent linear escarpment and truncated spurs of Lower Lytle Creek Ridge, as well as right-laterally deflected drainages and sidehill benches.

Southeast of GHRP, the Glen Helen fault is well-defined by a linear drainage, right-laterally deflected drainages and scarps. Faint tonal lineaments and a short trough suggest possible extensions farther to the southeast in young alluvium. The easterly branch east of GHRP, previously zoned and also mapped by Morton and Matti (1991a) as a bedrock fault, could not be verified as an active fault on air photos.

<u>San Andreas and Related Faults</u>

This fault is the most active fault in the Devore quadrangle and is well-defined by a narrow zone of linear scarps, sidehill benches, right-laterally-deflected drainages, and other features which coincide with the traces mapped by Weldon (1986) and Morton and Matti (1991a). Not all of these features are plotted on Map 2a. To the southwest, well-defined scarps in latest Pleistocene to Holocene alluvium define the <u>Peters and Tokay faults</u>, both of which appear to be mainly extensional features.

To the northeast of the San Andreas main trace is a linear trace of Weldon which is locally marked by a right-laterally deflected drainage (?), sidehill bench, and linear drainage in sections 20 and 21. To the southeast, this strand may connect with a linear fault that offsets late Pleistocene alluvium and is marked by a short scarp. Another possible active fault just northeast of the main trace is defined by a northeast-facing scarp in latest Pleistocene to Holocene alluvium at Cable Canyon.

The north-facing scarp in the northern part of sections 25 and 26 appears to be a fault line feature (i.e. mostly erosional) that may have been active in Pleistocene time. The thrust faults of Morton and Matti that connect with it to the west could not be verified as active, although an eroded scarp is present in one place. The northeast facing scarp in bedrock in section 23 is fairly young-looking and probably Holocene in age. However, its position along a ridgetop suggests that it is a ridgetop spreading feature caused by shaking rather than an active fault.

SEISMICITY

Figure 3 shows the epicenters of recent earthquakes in the vicinity of the study area (Magistrale and Sanders, 1994). The San Jacinto fault zone is fairly well highlighted by seismicity, though it appears to be shifted 2-3 km to the northeast. The zone steps to the right just east of the study area at the heavy black line on Figure 3. Within the study area, the seismicity closely aligns with the Glen Helen fault.

Another seismic zone aligns with the northeast-trending Barrier J of Dutcher and Garrett (1963). Another northeast trending seismic zone near Fontana aligns with the southwest projection of the Barrier J seismic zone. A swarm of M2 earthquakes occurred in the Fontana area beginning mid-July 1994, according to the Southern California Seismographic Network of Caltech and the USGS. This seismic zone was previously recognized by Hadley and Combs (1974).

A third, but weaker, seismic zone appears to follow the Stoddard Canyon fault, which also is not known to have surface activity. A dense cluster of epicenters also occurs at the west end of the Cucamonga fault at the west end of the study area.

CONCLUSIONS AND DISCUSSION

The study area occupies an actively deforming segment of the Transverse Ranges developed in the compressive bend of the San Andreas fault zone. The regional tectonics of the central Transverse Ranges is discussed in-depth by Matti and others (1992).

As a result of the compression, the north-dipping Cucamonga thrust fault developed on the south margin of the uplifted San Gabriel Mountains. While the fault is only 14 miles long as a surface feature, it probably connects at depth with the Sierra Madre thrust fault to the west. Total displacement on the Cucamonga fault is not known, but must be large considering the uplift of the San Gabriel Mountains (local relief is more than a mile). Evidence of Holocene displacement is abundant on several strands of the fault that developed well-defined fault scarps in latest Pleistocene to Holocene alluvium. The fault was determined to have a slip rate of 5 mm/yr in the last 13,000 years and to have vertical displacements of 2m 18 times during that period (Morton and Matti, 1987). If correct, this would give a fault-rupture event once every 625 years.

The Etiwanda fault appears to be a subsidiary thrust of the Cucamonga fault whose activity is defined by a scarp in latest Pleistocene-Holocene alluvium. There is no evidence that it connects with the concealed Red Hill fault to the southeast. The Powerline fault, mapped as a possible minor Holocene fault by Morton and Matti (1987, 1991a), was not verified as active by trenching and lacked supporting geomorphic evidence. The same is true for the inferred northernmost fault north of the main Cucamonga fault on the Mt. Baldy quadrangle. The concealed Red Hill fault on the Cucamonga Peak quadrangle could not be verified by trenching or by geomorphic features.

The San Jacinto fault zone appears to truncate the Cucamonga fault on the east. The former is a 3-mile wide zone of right-lateral strike-slip faults that merge with the San Andreas fault to the north. To the southeast of the study area, the San

Jacinto fault zone has had about 25 km of right-lateral displacement and a slip rate of 8 to 12 mm/yr (Matti and others, 1992).

Based on the well-developed breccia zones in bedrock, multiple branches and central position, the San Jacinto fault presumably is structurally the most significant fault in the zone within the study area. Holocene evidence is sparse along the fault and recent fault-produced geomorphic features are not well developed, suggesting that Holocene activity is relatively low or discontinuous along the fault. Holocene alluvium may be offset in two places, according to Morton and Matti (1987, 1991a); but mostly the fault is confined to older bedrock or is shown to be concealed by young alluvium. Trenching suggests the main trace of the fault is active in two other places. The position of Holocene active traces in the eastern Devore quadrangle is suggested by tonal and linear scarps in young alluvium that may connect the bedrock trace to the northwest with field- and trench-verified Holocene traces that flank Lytle Creek wash to the southeast in the San Bernardino North quadrangle (Map 2a).

The Lytle Creek fault is a western strand of the San Jacinto fault zone. Based on a scarp in latest Pleistocene to Holocene alluvium and associated geomorphic features, the southern part of the fault appears to be Holocene active. At Texas Hill a late Quaternary slip rate of 2 mm/yr has been determined. The activity appears to diminish to the northwest, based on progressively weaker geomorphic features.

The Glen Helen fault appears to be the most active member of the San Jacinto fault zone. Although only 13 miles long, it appears to be connected with the San Jacinto fault to the south via a complex right step. This stepover is partly defined by surface evidence (Map 2a) and by a right-step or bend in the well-developed zone of seismicity (Figure 3).

The San Andreas fault is the most active fault in the study area and has a Holocene slip rate of 25 mm/yr in Cajon Pass just north of the study area. The main trace is very well defined by a narrow zone of linear scarps in late Pleistocene and Holocene alluvium and associated right-deflected drainages and other features indicative of active faulting.

The Peters and Tokay Hill faults to the southwest also are Holocene-active based on well-developed linear scarps that offset latest-Pleistocene to early Holocene alluvium. They are considered to be normal faults, although the orientation of the Tokay Hill fault (subparallel to the San Andreas) suggests a right-lateral component of slip. Assuming the upper fan surface on these faults is about 10,000 ybp and the maximum scarp height is 5m (estimated from air photos), then these faults would have maximum vertical slip rates of 0.5 mm/yr.

Little is known about the activity of bedrock faults that lie north of the Cucamonga fault and west of the Lytle Creek fault. These faults are probably related to the uplift and compression associated with the bend in the San Andreas fault, but their timing is unknown as they do not offset young geologic units. A review of the Duncan Canyon fault, shown to be right-lateral by Morton and Matti (1987, 1991a), did not reveal evidence of systematically displaced drainages or ridges or young geomorphic features. Likewise, the topographic maps do not reveal evidence that would suggest the other faults in the San Gabriel Mountains are active. However, based on the location and orientation of these faults in the actively uplifting mountain range, it would not be surprising if one or more of these faults had at least minor Holocene activity.

No evidence was found that suggests that Barrier J of Dutcher and Garrett (1963) or the Red Hill fault -- both inferred groundwater barriers -- are surface features. A northeast trending zone of seismicity, however, locally coincides with barrier J (Figure 3).

RECOMMENDATIONS

Under current criteria, a fault must be "sufficiently active" (i.e. Holocene) and "well-defined" as a surface feature before it is zoned under the Alquist-Priolo Act (Hart, 1994). Based on these criteria and on the results of this study, the following recommendations are made:

1. Revise the Cucamonga fault as shown on Maps 3a, 3b, and 3c based on the recent mapping of Morton and Matti (1987, 1991a, 1991b) and this FER. However, minor zone modifications may be necesssary on Map 3c based on trench data in the Richard Mills Associates reports (AP-2126), which was uncovered after the Preliminary zone maps were prepared.

2. Retain the Etiwanda fault, with only slight revision (Map 3b) based on Morton and Matti (1987, 1991b).

3. Revise the Lytle Creek, San Jacinto and Glen Helen faults as shown on Map 3a, based on the recent work of Morton and Matti (1987, 1991a), this FER, and Rasmussen and Associates (1994a, 1994b).

4. Revise the San Andreas, Peters and Tokay Hill faults as shown on Map 3a based on Morton and Matti (1991a), Weldon (1986), and this FER.

5. Do not zone the bedrock faults north of the Cucamonga fault and west of the Lytle Creek fault as they lack evidence of Holocene activity.

6. Do not zone the Red Hill fault, barrier J, or the concealed southeast extensions of the Lytle Creek and San Jacinto fault shown on Maps 1a, 1b, 2a, and 2b as they are not defined as surface features.

7. Other minor faults shown on Maps 1a, b, c and 2a, b, c but not shown on Maps 3a, b, c either do not appear to be Holocene or are not well-defined and should not be zoned.

Report prepared by:

John L. Burnett
Associate Geologist
EG 718

Earl W. Hart
Senior Geologist
EG 935

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Appendix

Consulting Reports Reviewed

Following is a summary of unpublished fault-investigation reports, many with trench data. Each is summarized in the following format:

1. Report file number. The AP file numbers are consultants reports and were done for sites in an existing Alquist-Priolo zone. The C file numbers are reports for sites not in an existing Alquist-Priolo zone. Reports cited are on file with the Division of Mines and Geology, San Francisco.

2. Consulting firm, project number of report.

3. Partial title and location of the study.

4. Date of the report.

5. Summary of results and comments. Trench locations are shown on Maps 2a, 2b and 2c.

1. AP-198
2. Leighton and Associates, Inc., Project No. 2173.
3. Tentative Tract 8612 and Adjacent Areas, Riverside Avenue north of Galway Street, Rialto. 2000 feet east of the Devore quadrangle, 1 mile southeast of the Rancho Verde Country Club (San Bernardino North quadrangle).
4. 8/24/72, 12/12/75, 3/1/76, 3/10/76.
5. The site is adjacent to the projected location of the San Jacinto fault, but trenching was not done.

1. AP-488
2. Gary S. Rasmussen and Associates, Inc., Project No. 1213.
3. Tentative Tract No. 9001. One mile northwest of Rancho Verde Country Club (San Bernardino North quadrangle).
4. 6/20/77
5. The site is located on the projected trace of the Lytle Creek or San Jacinto fault zoned in 1974. No evidence of faulting was found in a trench 781 feet long by 10 feet deep in younger and older alluvium.

1. AP-649
2. Gordon Clopine.
3. Lake Devore Mobile Home Estates. One mile northeast of Devore (Devore quadrangle).
4. 11/15/77
5. The Tokay Hill fault was found to offset Pleistocene alluvium in trench 80 feet long. Fault assumed to be active based on surface evidence.

1. AP-1507
2. Gary S. Rasmussen and Associates, Inc., Project No. 1739-2.
3. NW of the Intersection of Meyers Road and Martin Ranch Road. 1.5 miles east of Devore on the San Andreas fault (Devore quadrangle).
4. 7/17/81
5. Three trenches with two short subsidiary trenches. Faulting was found in Holocene and late Pleistocene alluvium in all three main trenches across zone about 350 ft wide.

1. AP-1529
2. Eberhardt-Axten and Associates, Work Order 1176.
3. Tract 11626, Rancho Cucamonga. Located at the base of the San Gabriel Mountains, Rancho Cucamonga (Cucamonga Peak quadrangle).
4. 11/14/80 and 4/27/83.
5. Shallow trenches (max. depth of 6 ft) totaling 2,438 feet in length were excavated in young alluvium. The Cucamonga fault, although reportedly extending through the site, was not observed in the trench walls.

1. AP-1860
2. Gary S. Rasmussen and Associates, Inc., Project No. 2096.1
3. Proposed Maintenance Building, SE of Redwood Lane and Kenwood Avenue, Devore. 2000 feet west of Tokay Hill (Devore quadrangle).
4. 11/19/84, 1/21/85, 4/11/85
5. 166 feet of trench revealed no faulting on the site. The site is just north of the Peters fault.

1. AP-1874
2. Leighton and Associates, Inc., Project No. 6840991-02.
3. Fault Investigation at Deercrest Drive and Foothill Street, Devore Area. Northeast flank of Tokay Hill (Devore quadrangle).
4. 9/24/84, 1/23/85
5. A trench excavated in 3 sections did not reveal evidence of faulting.

1. AP-1876
2. Geological Systems Evaluation Corp.
3. 1144 Deercrest Drive, Devore. East flank of Tokay Hill (Devore quadrangle).
4. 8/9/85, 11/5/85
5. 225 feet of trench did not reveal faulting.

1. AP-1885
2. Earth Technics. Project No. 85102-01.
3. Tract 12827, Devore area; exact location uncertain (Devore quadrangle).
4. 4/19/85, 6/7/85
5. 280 feet of trench revealed no displacement. The trench site is just south of the Peters fault.

1. AP-1902
2. Gary S. Rasmussen and Associates, Project No. 2249.
3. Rocco's Corner. Located at Nealey's Corner (Devore quadrangle).
4. 4/16/86
5. Two trenches to ten feet deep totaling 255 feet were excavated in alluvium estimated to be 3000-4000 years old. No evidence of surface faulting was found.

1. AP-2005
2. Southern California Soil and Testing, Inc.
3. 2565 Euclid Cresent East. Located in the San Antonio Heights, Rancho Cucamonga (Mt. Baldy quadrangle).
4. 7/27/84
5. Two trenches exposed steeply north-dipping faults in alluvium estimated to be younger than 100,000 years overlain by unfaulted modern alluvium; building setback recommended. Trench profiles reflect broad south-facing scarp in alluvium at Morton and Matti trace.

1. AP-2014
2. John R. Byerly, Inc., Report No. 4506.
3. SE of Devore Road and Foothill Street, Devore Area (Devore quadrangle).
4. 1/30/87
5. Three trenches yielded no evidence of active faulting.

1. AP-2015
2. Pioneer Consultants, Job No. 4209-001.
3. Proposed Residence, London Avenue. Located in a wash near the base of the San Gabriel Mountains, north of Rancho Cucamonga (Cucamonga Peak quadrangle).
4. 12/12/86, 12/31/86
5. Two trenches in "older alluvium" did not reveal any evidence of surface faulting, but may have been south of the fault.

1. AP-2058
2. Richard Mills Associates, 87-145-01.
3. Portion of Sections 13 and 14. Located at the base of the San Gabriel Mountains at Lytle Creek Road (Devore quadrangle).
4. 7/7/87
5. Three short trenches did not reveal surface faulting in older alluvium. However, trench 2 showed a sharp break in slope (scarp?).

1. AP-2062
2. Gordon A. Clopine
3. 9.9 acre portion of the northeast quarter of Section 22 near Scotland on the North Fork of Lytle Creek (Devore quadrangle).
4. 10/14/87
5. 600 foot trench shows Holocene alluvium offset by the San Jacinto Fault.

1. AP-2063
2. Earth Technics, Project No. 87114-01.
3. 4 - Lot Subdivision. Located northwest of Tokay Hill (Devore quadrangle).
4. 4/15/87
5. 347 linear feet of trench in two separate trenches did not reveal faulting.

1. AP-2123
2. Leighton and Associates, Inc., Project No. 280572-01
3. Tentative Tract No. 10088, Rancho Cucamonga. Located at the base of the San Gabriel Mountains (Cucamonga Peak quadrangle).
4. 8/11/80 and 8/26/86
5. A shallow 500 foot trench in late Quaternary alluvium revealed no surface faulting. Precise location of trench is unknown (site map is missing from report).

1. AP-2124
2. Highland Geotechnical Consultants, Job No. 6081-00
3. Tentative Tract 10277, Rancho Cucamonga. Located at the base of the San Gabriel Mountains (Cucamonga Peak quadrangle).
4. 2/21/85 and 5/22/85
5. 480 feet of shallow trenching reportedly did not reveal surface faulting. However, both trench logs show anomolous features near the mapped trace of the Cucamonga fault.

1. AP-2125
2. J. H. Kleinfelder and Associates, T-365.
3. The Woods at Rancho Cucamonga. Located at the base of the San Gabriel Mountains in Rancho Cucamonga (Cucamonga Peak quadrangle).
4. 1/27/81
5. 5 out of 9 trenches exposed the Cucamonga fault in older and younger alluvium; building setback recommended.

1. AP-2126
2. Leighton and Associates, Project No. 677027-01 and -02; Richard Mills Associates, Project No. 88-318-01 and 89-033-01.
3. 196-lot (200 acre) Subdivision northwest of Sapphire and Almond Streets, Alta Loma (Rancho Cucamonga), including Tract No. 10210 and Skyline Phase III (Mt. Baldy quadrangle).
4. 5/31/78, 7/21/78 (Leighton) and 11/5/82, 11/28/88, 6/2/89 (Mills)
5. Leighton excavated seven shallow trenches totalling 943 feet in 1978; concluded that two strands of the Cucamonga fault were active; a third suspected fault was not found. Later deep trenching was conducted by Mills in 1988 (Tract 10210) and 1989 (Skyline Phase III). About 2700 feet of trench in Tract 10210 verified and refined the location of Morton and Matti's (1987) main active trace at six fault crossings. In the north part of the original subdivision, Mills excavated 2800 feet of trenches up to 20-ft deep and 419 feet of bank cuts across three inferred traces: the west and southwest extensions of Morton and Matti's north trace and the north trace that Leighton concluded as active. None of these traces were verified in alluvium of mid-Holocene to latest Pleistocene ages.

1. AP-2356
2. Craig Smith
3. Five Lot Subdivision, SW Corner of Foothill and Knoll Streets, Devore. Located on Tokay Hill (Devore quadrangle).
4. 4/19/88
5. A 620-foot trench did not reveal faulting on either the Tokay Hill or San Andreas fault(?). Trench log seems generalized.

1. AP-2431
2. Gary S. Rasmussen and Associates, Inc., Project No. 2739.
3. Proposed Oak Summit Development, Rancho Cucamonga. Located at the mouth of Day Canyon (Cucamonga Peak quadrangle).
4. 12/29/89
5. The traces of the Cucamonga fault were exposed in alluvium in most of the 18 trenches which totaled 9500 feet in length. All faults are considered active.

1. AP-2621
2. Gary S. Rasmussen and Associates, Inc., Project No. 3079.
3. Parcel 1, Tentative Parcel Map 12852. On Tokay Hill, 1 mile north of Devore (Devore quadrangle).
4. 10/29/91, 2/21/92
5. No fault found in 176-ft long trench in older alluvium.

1. AP-2645
2. Gary S. Rasmussen and Associates, Inc., Project No. 3119.
3. Proposed Amphitheater, Glen Helen Regional Park. The southeastern portion of Glen Helen Regional Park (Devore quadrangle).
4. 7/13/92, 8/4/92
5. Sixteen trenches totaling 2,059 linear feet were excavated. Active and potentially active faulting was found in the Glen Helen fault zone. The main zone is 45 feet wide, trends N40W and dips steeply northeast and southwest. A northeast-facing scarp 20 feet high marks the main trace of the fault. Other subsidiary faults outside of this zone were also located. Bedding locally is warped and contorted suggesting past liquefaction.

1. AP-2707
2. Gary S. Rasmussen and Associates, Inc., Project No. 3185.
3. Woodlawn and Kimbark Avenues. South part of Devore Heights (Devore quadrangle).
4. 9/24/93
5. One trench 343 feet in length revealed no evidence of the Peters fault.

1. AP-2737
2. Geolabs-Westlake Village, Work Order 7526.
3. Hunter's Ridge Area, Fontana. Located at the base of the San Gabriel Mountains at San Sevaine Canyon (Devore quadrangle).
4. 4/28/87
5. 64 test pits and short trenches were excavated mainly for geotechnical purposes. The file copy of the report does not have a site map showing the trench and pit locations. Refers to a 1984 report by Pacific Soils which may have evaluated the Cucamonga fault at this site.

1. AP-2750
2. Gary S. Rasmussen and Associates, Project No. 2837.
3. 160 Acre Development, Portion of Section 16, Rancho Cucamonga. Located at the base of the San Gabriel Mountains, one mile east of Day Canyon (Cucamonga Peak quadrangle).
4. 4/18/90
5. 14 trenches with a total length of 6000 feet were excavated. Five strands of the Cucamonga fault were identified but only three showed evidence of Holocene movement and were recommended for building setbacks.

1. AP-2751
2. Gary S. Rasmussen and Associates, Inc., Project No. 2248.
3. Southern Glen Helen Ranch Property and Adjacent Lytle Creek Wash. Located around the Glen Helen Rehabilitation Facility, 3 miles south of Devore (Devore quadrangle).
4. 4/14/86, 4/14/86, 11/12/86, 5/4/88, and 7/25/94
5. A preliminary examination involving limited trenching, one of which crossed the Dutcher and Garrett trace without revealing faults in a 5,000 year old alluvium (11/12/86 report). Based on photo interpretation, new locations for the San Jacinto and related subsidiary faults are shown.

1. AP-2756
2. Gary S. Rasmussen and Associates, Inc. Project No. 2957 and 2957.1.
3. The Kimbark Elementary School site in Devore (Devore quadrangle).
4. 10/4/90 and 7/8/93
5. Two reports on the same school site on the Peters fault. A total of 360 feet of trench showed Holocene sediments faulted against Pleistocene sediments. Trench locations are approximate.

1. AP-2795
2. Gary S. Rasmussen and Associates, Inc., Project No. 1825.
3. Tentative Tract 11408, NE of Riverside Avenue. Located 2/3 of a mile southeast of El Rancho Verde Country Club (San Bernardino North quadrangle).
4. 8/25/82
5. Six trenches for a total of 2,700 feet were excavated. Four of these trenches showed evidence of Holocene surface rupture along the San Jacinto fault considered to be the main trace of the fault. Partly the same site as AP 2796.

1. AP-2796
2. Gary S. Rasmussen and Associates, Inc., Project No. 3156.1.
3. El Rancho Verde Country Club, Rialto, CA.
4. 1/5/93, 6/9/94, 8/9/94
5. 23 trenches totaling 3600 feet were excavated. 13 of 23 trenches for this investigation showed active or potentially active faulting. Includes previous work done at site AP 2795.

1. C-652
2. Ray A. Eastman, Project No. 565.
3. Proposed Development, NW Corner of Haven Avenue and Southern Pacific Railroad. Located one mile east of Alta Loma (Cucamonga Peak quadrangle).
4. 11/2/87
5. The site is partially located in a "Special Studies Zone" established by the City of Rancho Cucamonga along the inferred Red Hill fault. Slightly less than 600 feet of trench in two locations did not reveal surface faulting.

1. C-664
2. Richard Mills Associates, Inc., S-160.
3. Tract No. 9454. Located on the east side of Haven Avenue, 1300 feet north of Baseline Road in Rancho Cucamonga (Guasti quadrangle).
4. 4/19/79
5. The proposed tract is located on the projected trace of the Red Hill fault. One trench was excavated and no evidence of surface faulting was found.

1. C-666
2. Ray A. Eastman, Project 442.
3. Proposed Building Site, SE Corner of Foothill Blvd. and Baker Ave. Located on the Red Hill fault, south of Red Hill (Guasti quadrangle).
4. 1/9/87
5. No surface faulting found in a trench.

1. C-667
2. Richard Mills Associates, Inc., 86-262-11.
3. Hellman Avenue South of Church Street (Guasti quadrangle). One half mile east of Red Hill.
4. 12/5/86
5. Two trenches totaling 680 feet were opened in a "Special Studies Zone" established by the City of Rancho Cucamonga. No surface faulting was revealed.

1. C-721
2. Gary S. Rasmussen and Associates, Inc., Project No. 2390 and 2390.2.
3. 300 Acres, Portions of Sections 20 and 29. One mile northwest of Etiwanda (Cucamonga Peak quadrangle).
4. 6/8/87
5. A trench 426 feet long, excavated near the Red Hill fault, did not reveal surface faulting.

1. C-738
2. Petra Geotechnical, Inc., Job No. 296-88.
3. Commercial Center, SE Corner of Highland and Miliken Avenues. One mile southeast of Chaffee Union Junior College (Cucamonga Peak quadrangle).
4. 11/3/89
5. Two trenches totaling 900 feet did not reveal surface faulting related to the Red Hill fault.

1. C-898
2. Gary S. Rasmussen and Associates, Inc., Project No. 2390.2 and 2390.4
3. Site Addition, N 1/4 of Section 20, T1N, R6W, SBB&M, North of Rancho Cucamonga (Cucamonga Peak quadrangle).
4. Three trenches totaling 580 linear feet on the Powerline fault showed late Pleistocene thrust faulting with subsidiary high-angle faults in a zone 100 feet wide. Based on scarp angle of 13-14°, fault not considered active in last 15,000 years.

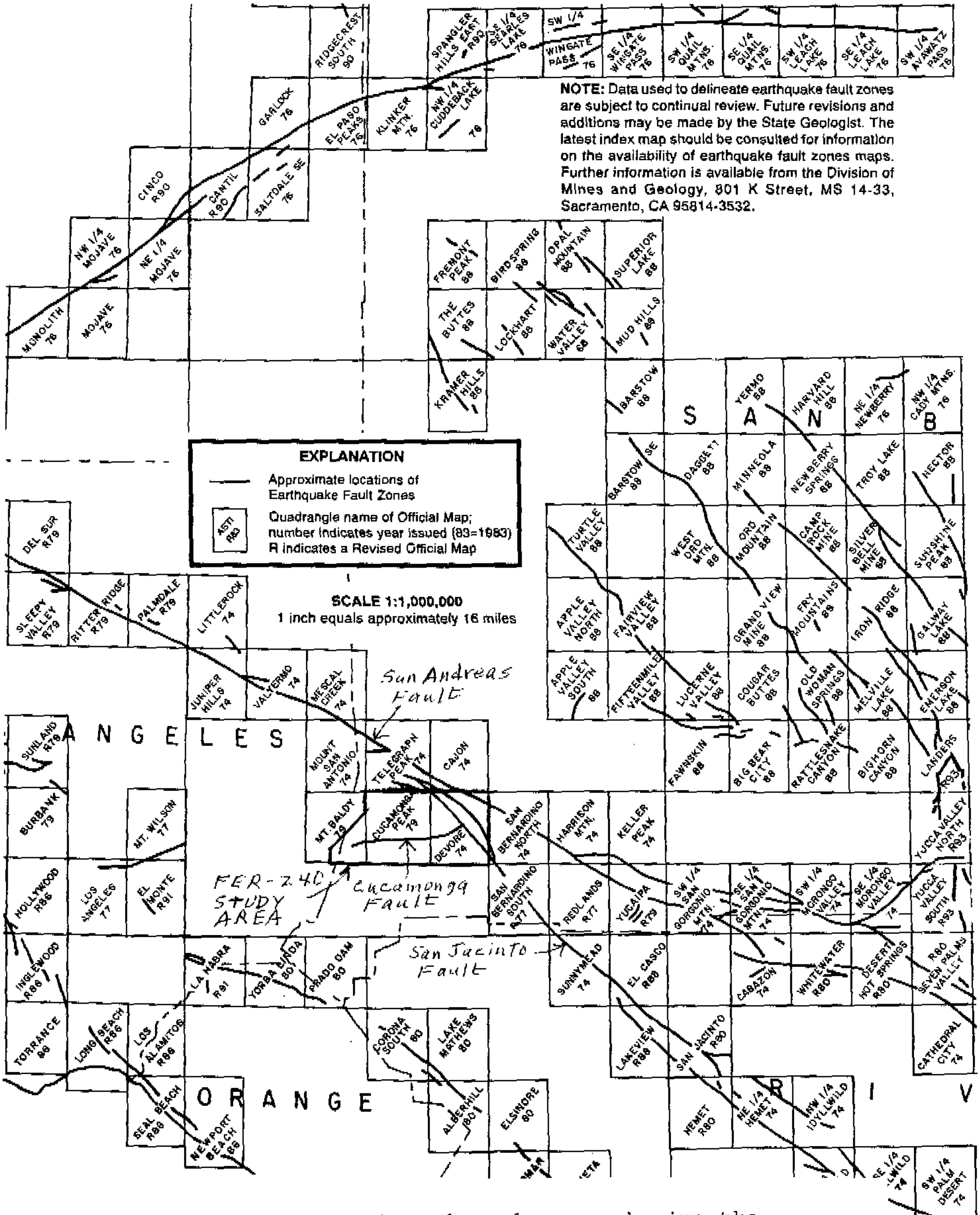


Figure 1 (FER-240). Location of study area showing the Earthquake Fault (Special Studies) Zones and principal faults evaluated (base map from Hart, 1994).

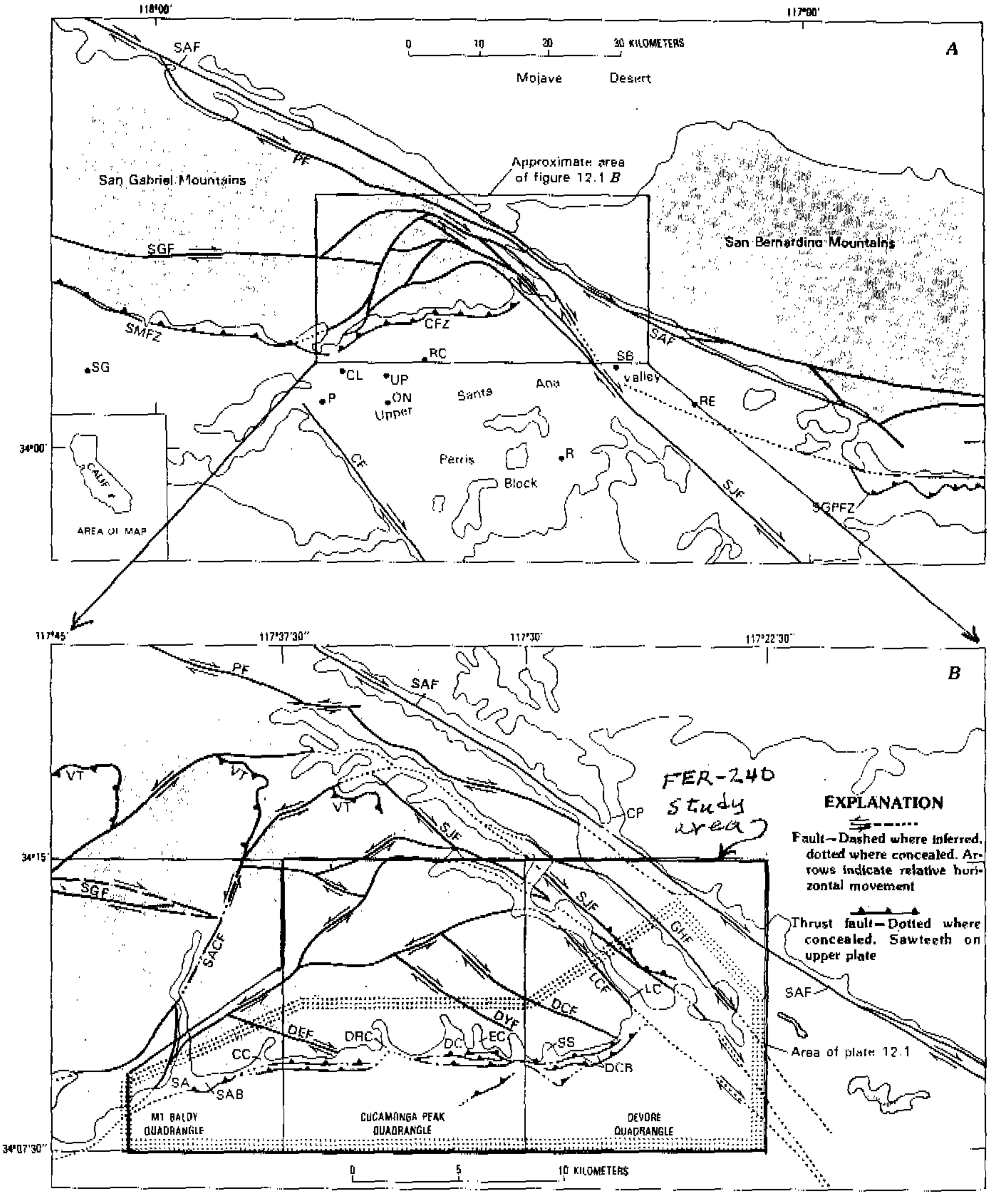


Figure 2 (FER-240). Locations and tectonic setting of the Cucamonga, San Jacinto, San Andreas, and related faults in the study area (from Morton and Matti, 1987). Major faults are: CFZ -- Cucamonga fault zone; SAF -- San Andreas fault; SJF -- San Jacinto fault; GHF -- Glen Helen fault; LCF -- Lytle Creek fault; SMFZ -- Sierra Madre fault zone.

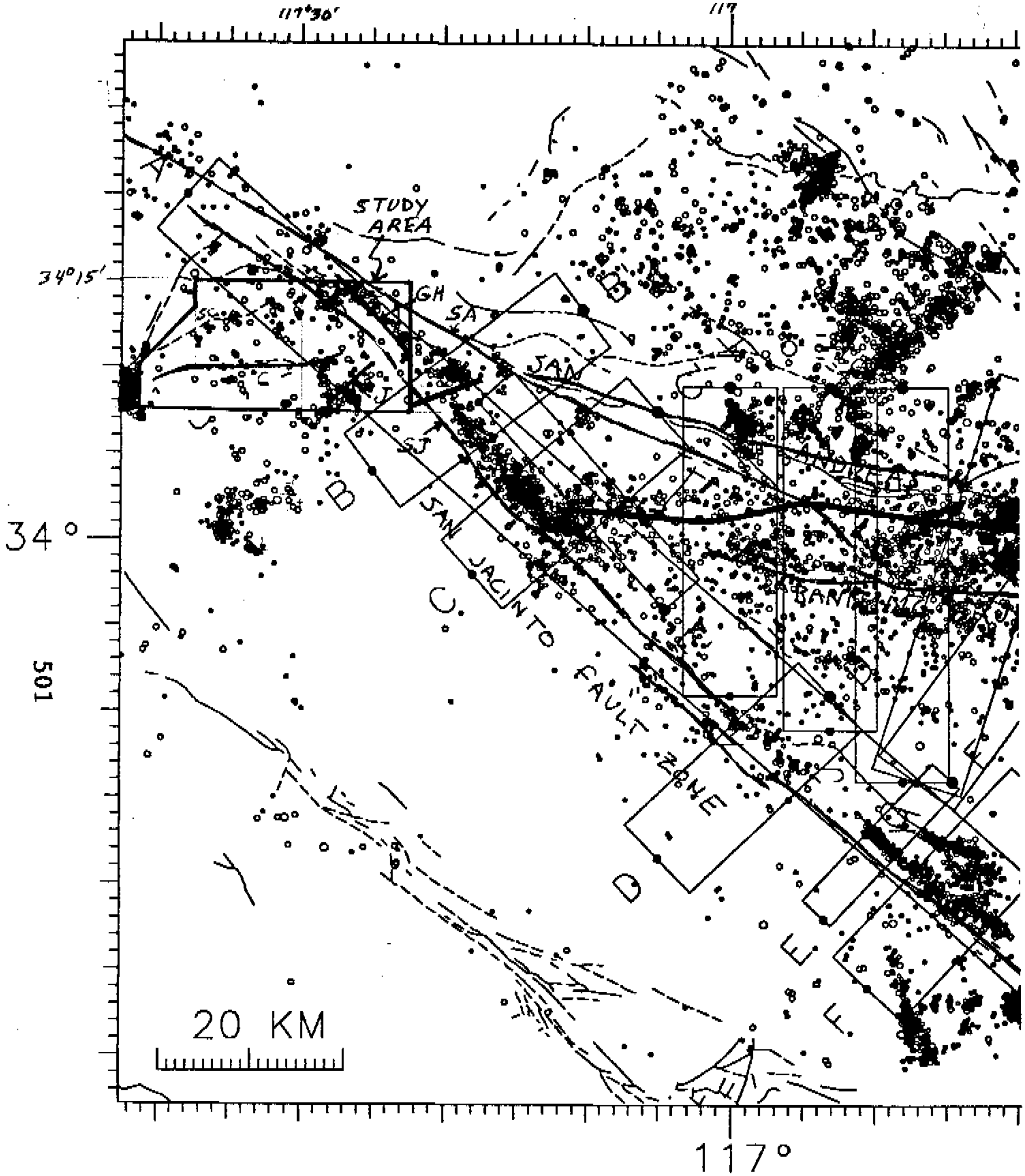
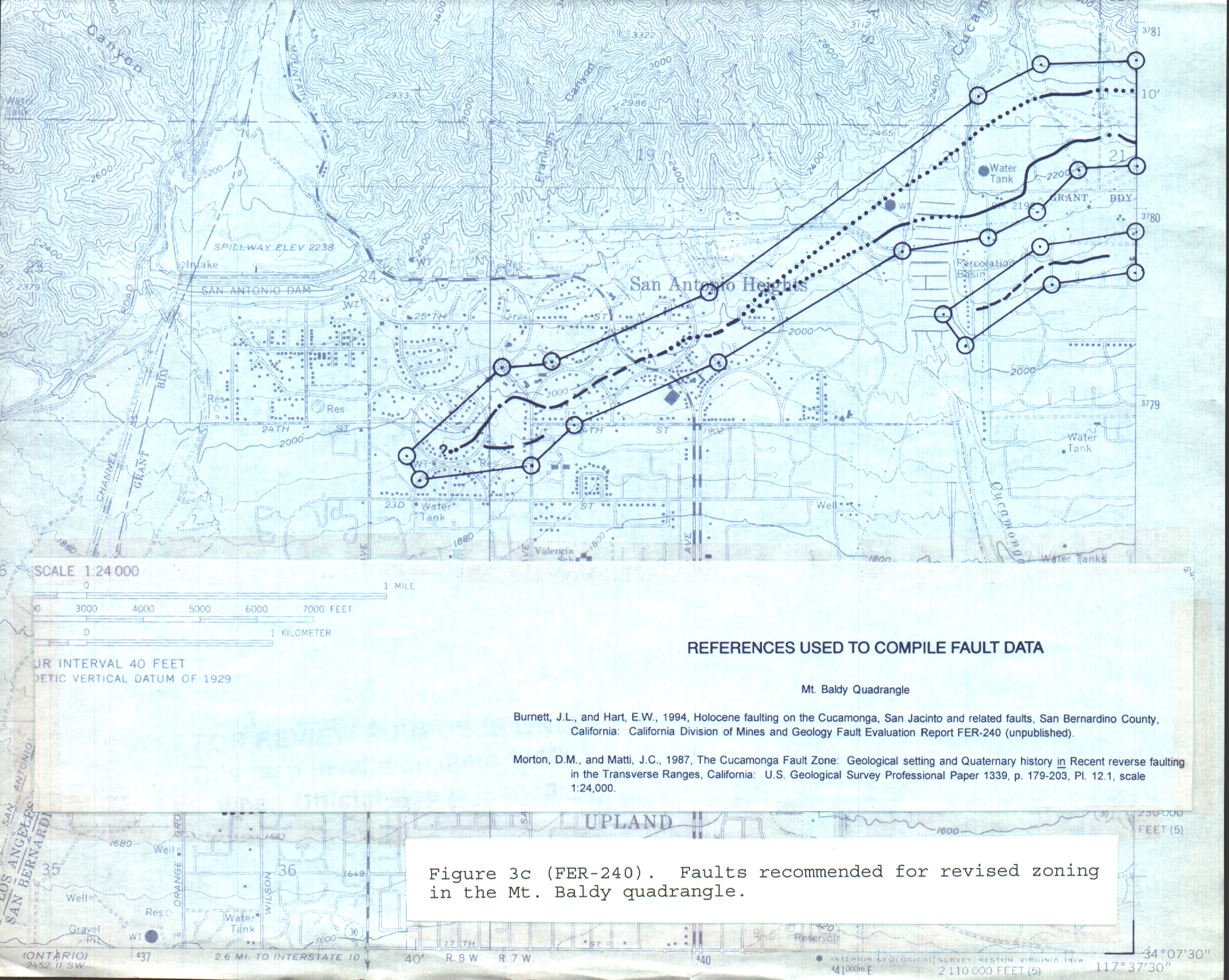


Figure 3 (FER-240). Seismicity in the central Transverse Ranges and relation to active faults (from Magistrale and Sanders, 1994). Faults are C = Cucamonga, GH = Glen Helen, J = Barrier J, SA = San Andreas, SC = Stoddard Canyon, SJ = San Jacinto.



REFERENCES USED TO COMPILE FAULT DATA

Mt. Baldy Quadrangle

Burnett, J.L., and Hart, E.W., 1994, Holocene faulting on the Cucamonga, San Jacinto and related faults, San Bernardino County, California: California Division of Mines and Geology Fault Evaluation Report FER-240 (unpublished).

Morton, D.M., and Matti, J.C., 1987, The Cucamonga Fault Zone: Geological setting and Quaternary history in Recent reverse faulting in the Transverse Ranges, California: U.S. Geological Survey Professional Paper 1339, p. 179-203, Pl. 12.1, scale 1:24,000.

Figure 3c (FER-240). Faults recommended for revised zoning in the Mt. Baldy quadrangle.